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(54) METHOD OF RECOVERING SEMICHEMICAL AND KRAFT FIBRES SEPARATELY FROM CORRUGATED BOARD

(71) We, ARTHUR D. LITTLE INC., a Corporation organised and existing under the laws of the State of Massachusetts, United States of America, of Acorn Park, Cambridge, Massachusetts 02140, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method for separating two types of fibres found in paper composites and more particularly to seperating the semichemical fibre constituent from the kraft fibre constituent in corrugated board in the recycling of corrugated boxes and the like.

In the recovery of secondary fibres from a composite of paper or of a paperboard product such as container board, it is necessary to be able efficiently to separate the constituent fibres to obtain maximum utility of each type of recovered fibres.

Conventional corrugated board comprises two outer layers of linerboard made of softwood kraft fibres and an inner layer of corrugated medium formed of hardwood semichemical fibres. The function of the outer layers of linerboard is to provide the packaging material with high resistance to punctures and tears. The linerboard makes up approximately two-thirds of the total weight of the container board and has outstanding high strength characteristics. The principal function of the corrugated medium is to provide impact resistance to the corrugated board, and by comparison with the linerboard it has poor physical strength characteristics. The semichemical corrugated medium has a low moisture resistance or high water receptivity, while the kraft linerboard has a high moisture resistance or low water receptivity. This marked difference in water receptivity and strength characteristics of the two constituents of corrugated board are used in the separation method of this invention.

In the present known processes for recycling corrugated board, old corrugated boxes and the like (shredded or whole) are thoroughly mixed into water to be dispersed and formed into a pulp slurry. Usually, such a slurry contains about 5% by weight of fibrous material and 95% by weight of water. In forming the fibre slurry by this prior art process, the semichemical fibres from the corrugated medium fraction and the kraft fibres from the linerboard fraction become intimately mixed. Since there is no satisfactory way of separating these two kinds of fibres they must be processed and reused as a fibre mixture. This fibre mixture is cleaned to remove heavy inorganic materials and then treated with a mild cooking action to disperse contaminants such as asphalt, plastics and the like. The resulting fibre mixture can then be formed into either recycled linerboard called "jute liner" or recycled corrugated medium called "bogus medium" depending on the process conditions used. In spite of the fact that different process conditions are used, it has been demonstrated that the presence of both types of fibres in the manufacture of either type of product is detrimental to the attainment of the characteristics desired in the products. More specifically, the presence of semichemical fibres in jute linerboard detracts from its physical strength; while the presence of kraft fibres in the bogus medium is detrimental to attaining the desired degree of stiffness.

The difficulties encountered in using such a fibre mixture in producing reconstituted corrugated board have led to a number of different attempts to effect an efficient, economic separation of the semichemical fibres from the kraft fibres. For example, in one known experimental process, the pulp slurry

containing both kinds of fibres is passed through a centrifugal separator to segregate the long softwood kraft fibres from the short hardwood semichemical fibres. However, it is believed that this process has not been demonstrated to be economically feasible.

It is therefore apparent that there is need for an efficient, economic method for processing corrugated board to be recycled so that a substantial portion of the two types of fibre constituents can be separated and reused to the best advantage.

It is therefore a primary object of this invention to provide a method for separating and recovering the semichemical fibres and the kraft fibres in corrugated board which is being recycled and reconstituted. It is another object to prove a method of the character described which produces two types of recovered fibres which may be used to the best advantage in forming reconstituted corrugated board, the properties of which approximate those of corrugated board made from all virgin fibres. Other objects of the invention will in part be obvious and will in part be apparent hereinafter.

By the method of this invention, the corrugated board stock material (boxes, separators, clippings etc.) is first subjected to a treatment which reduces the material to intermediate sized pieces, preferably of substantially uniform size. Then the pieces, after being treated with a debonding agent if desired, are introduced into water, which may contain a surfactant, and the resulting dispersion is subjected to mechanical action to achieve differential size reduction. The temperature of the water, the surfactant content and the time of and energy input into the mechanical action are adjusted so as to separate the corrugated medium from the liner board and to reduce the corrugated medium constituent to fibres or small pieces while retaining substantially all of the linerboard constituent relatively intact in the form of larger pieces. The smaller-sized pieces and fibres of the corrugated medium constituent are then separated from the larger-sized pieces of linerboard constituent such as by conventional screening techniques. Each fraction is then preferably subjected to well-known procedures for disintegration to reduce the separated fractions to fibres. Hand sheets made from fibres from these two fractions show marked differences in physical properties, thus providing evidence that the separation of the semichemical fibres from the kraft fibres is efficient.

The corrugated stock which is to be reclaimed and recycled may be such material as old boxes, corrugated scrap, sheets, box dividers and the like. It is preferably first sorted to remove such extraneous material as metal, cloth, dirt and the like. Then the corrugated board is reduced to intermediate sized pieces, the dimensions on any one side of the pieces ranging from about one to six inches giving the pieces two surfaces ranging in area from about 1 to 36 square inches. It is preferable that substantially all of these pieces for any one batch or run be of substantially uniform size, e.g. about 1×1, 1×6, 2×2, 2×6, etc. It will, of course, be appreciated that these sizes are only exemplary and very approximate. Uniformity of dimensions is preferable to ensure that substantially all of the intermediate sized pieces receive essentially the same treatment over a given period of time during the differential size reduction step. Thus, for example, if these intermediate-sized pieces were made up of a mixture of pieces which were 1×1 inch, 3×3 inches and 6×6 inches it becomes readily apparent that it would require different lengths of time for water to penetrate into the central portions of the corrugated mediums of these three differently sized pieces. Since the time over which mechanical working is performed is one important parameter in the differential size reduction step, it is apparent that it is preferable not to introduce an additional factor of wide size range of the intermediate sized pieces into the determination of the various operating parameters of this step.

During the step of reducing the corrugated board stock to intermediate sized pieces it may be desirable to add a small amount of a chemical debonding agent to the stock to reduce the possibility of undesirable fibre damage. Such a debonding agent is exemplified by water or a dilute water solution of urea, of ethylene carbonate, of a mixture of urea and ethylene carbonate or of a surfactant. The amount of such a chemical bonding agent solution should not exceed about 5% by weight of the corrugated stock.

The step of reducing the corrugated board stock to the intermediate sized pieces may be performed in one of several commercially available types of equipment. For example, a suitable size reduction mill such as a hammermill or a rotary cutter may be used. The latter is preferable since it produces pieces of corrugated board which have edges that are clean cut and uncompacted. Such edges permit the water, in which the pieces are dispersed, readily to penetrate into and through the corrugated medium to free it for reduction into small pieces.

After the corrugated board stock has been reduced to the intermediate sized pieces, the pieces are subjected to a differential size reduction step in which the semichemical corrugated medium constituent is materially reduced in size while the kraft linerboard constituent is retained in substantially its

intermediate sized condition. This differential size reduction step is carried out by dispersing the intermediate sized pieces in water which may contain a surfactant. The amount of corrugated board stock dispersed in water may range from about 1/2 to 10% by weight of water used. If a surfactant is used it may be an anionic, cationic or nonionic material, and it may range in amount up to 0.3%, and preferably between 0.1 and 0.3%, based on the weight of the water. The water into which the intermediate sized pieces are introduced for dispersing may range in temperature from ambient temperature up to about 160%F.

Once the pieces of corrugated board stock are introduced into the water for dispersion they are subjected to what may be termed low-energy mechanical action, over a period of time ranging from a few seconds to several minutes, the purpose of which is to separate the corrugated medium from the linerboard and to disperse the more water-receptive corrugated medium constituent into individual fibres or into small pieces, e.g., up to about 1/4 to 3/8 inch in size while the more water-resistant (less water-receptive) linerboard constituent remains essentially intact in the size of the original intermediate sized feed stock or is reduced to pieces considerably larger than 3/8 inch.

If the differential size reduction step is carried out as a batch operation, exemplary types of suitable equipment include, but are not limited to, a pulper, a propellor-type mixer operating between about 20 and 60 rpm. and a ball mill with glass balls ranging in size from about 1/4 to 5/8 inch in diameter. If this step is carried out as a continuous operation, exemplary types of suitable equipment include, but are not limited to, a pipeline type mixer wherein residence time is controlled by controlling the back-pressure and a continuous ball mill.

It is necessary to control the operational parameters in combination to obtain the dispersion of the corrugated medium semi-chemical fibres while minimising the dispersion of the kraft fibres of the linerboard. It is desired that if good differentiation of properties is to be maintained in the finally separated constituents that not more than about 20% of the kraft fibres originating from the linerboard constituent be dispersed. It is, however, preferable that this fraction of dispersed kraft fibres be kept at 10 to 15% or below. Ideally, of course, it would be most preferable if none of the kraft fibres were dispersed, but this is difficult to attain.

The operational parameters which must be adjusted to attain the desired dispersion as described are water temperature, surfactant content, the time period over which the mechanical action is applied and the level of energy input into the applied mechanical action. These parameters in combination must be adjusted to obtain the desired degree of dispersion. Some examples may be cited for guidance but not for placing limitations on any one parameter. If ambient temperature water is used containing a low concentration of surfactant and a low-level of energy input is employed, then the dispersing time may be several minutes, e.g., two to six minutes. If, on the other hand, the water is at an elevated temperature, the surfactant is present at a relatively high concentration, and the energy level input is greater, then the time required to achieve the desired degree of differential size reduction may be reduced to a minute or even less. Therefore, knowing the results (type of dispersion) required, the range of surfactant concentration, and the upper limit on dispersion water temperature, it is well within the skill of the art to determine residence time in any suitable equipment for any desired intermediate sized pieces of corrugated stock being processed.

After the attainment of the desired differential size reduction, the resulting slurry, containing as one fraction the small pieces or fibres of corrugated medium semi-chemical fibres and as the other fraction the intermediate sized pieces of linerboard, is subjected to a separation step whereby the two fractions are separated. This may be accomplished by use of a well-known continuously moving inclined screen or a rotary screen apparatus wherein the small pieces or fibres of the corrugated medium along with a small amount of the linerboard pass through the screen for collection and the larger-sized pieces of the linerboard are retained on the screen for separate collection. Alternatively, a vibrating screen apparatus may be used. It is also possible to employ apparatus based upon a flotation technique in which the larger pieces float to the surface of a flotation cell where they are skimmed off and thereby separated from the fraction of small pieces and fibres which sink to the bottom. During this separation step it may be preferable or necessary to dilute the slurry to a consistency best suited for the particular type of separation apparatus used. Typically, consistencies of from about 0.1 to 5% will be satisfactory. The choice of an optimal consistency is within the skill of the art.

Once the two types of fibres have been separated they may be handled in a conventional manner to be reprocessed into corrugated medium and linerboard. Alternatively, the recovered fibre fractions can be used for the manufacture of other types of paper or paperboard materials. For example, since the linerboard is formed of high quality fibres, this fraction formed primarily of softwood kraft fibres may be

bleached and used in high-value paper products.

The method of this invention may be described in further detail with reference to the following specific example which is meant to be illustrative and not limiting.

The stock used was obtained from old container board (corrugated board). After a preliminary cleaning, the container board was cut up into intermediate sized pieces which were generally uniform in size averaging out about one by one inch in dimension. In forming the intermediate sized pieces a paper cutter was used. No debonding agent was added during this step. The intermediate sized pieces were then added to water, at room temperature (about 64°F), which did not contain any surfactant. The amount of corrugated stock was 2% by weight of water used. This material was processed in a laboratory stirrer operating at 60 rpm for 5 minutes. The resulting slurry was diluted to a consistency of about 1/2% and the fibre fractions were separated by passing the slurry through a screen, the openings in which were 1/2 × 1/2 inch. Each fibre fraction was then formed into a papermaking furnish following TAPPI Standard Method No 410 for dispersing fibres for forming hand sheets. Hand sheets were then formed from the two furnishes on a Noble-Wood apparatus. The sheets were conditioned overnight at 50% relative humidity and subjected to standard test procedures to obtain the results tabulated in Table 1. For comparison, a hand sheet was also formed of a combination of semichemical kraft fibres obtained from a sample of the corrugated stock. The procedures for dispersing the fibres and forming the hand sheet were the same method as described.

Table 1
Physical Strength Characteristics of Fibres Reclaimed from Corrugated Board

Fraction	*Mullen (psi)*	*Total Wt. of Fraction (gm)*	*Weight (gm)**	*Freeness†*	*Tensile lbs/1in.*	*Tear (gm)*
Composite	16.0	41.1	2.68	570	8.2	83
Linerboard	18.2	69.0	2.65	610	11.2	116.6
Corrugated medium	8.25	31.5	2.64	650	6.6	32

* 64 square inches

† Canadian Standard Freeness

The physical data of Table 1 clearly show that the two fibre fractions possess markedly different strength properties, particularly tensile and tear strengths. These differences are evidence that the two types of fibres — semichemical from the corrugated medium and kraft from the linerboard — were effectively separated by the method of this invention.

WHAT WE CLAIM IS:—

1. A method for separating the semichemical fibre fraction forming the corrugated medium from the kraft fibre fraction forming the linerboard in corrugated board, comprising the steps of: (a) reducing corrugated board stock to intermediate sized pieces; (b) introducing said intermediate sized pieces of corrugated stock into water for dispersion therein; (c) subjecting said corrugated stock in water to differential size reduction by mechanical action, the temperature of said water and the length of time and energy level input of said mechanical action being adjusted to separate said corrugated medium from said linerboard and to reduce said corrugated medium fraction to fibres or small pieces while retaining substantially all of the kraft linerboard fraction in the form of larger or intermediate sized pieces; and (d) separating said fibres and small pieces of said semichemical corrugated medium fraction from said kraft linerboard fraction.

2. A method in accordance with claim 1 including the step of adding a debonding agent to said corrugated board stock prior to said reducing step (a) thereby to minimize fibre breaking.

3. A method in accordance with claim 1 or claim 2 including the step of adding a surfactant to said water prior to step (b), the concentration of said surfactant being up to 0.3% by weight of said water.

4. A method in accordance with any of claims 1 to 3 wherein said corrugated board stock is reduced in size to form said intermediate sized pieces with dimensions ranging between about 1 and 6 inches.

5. A method in accordance with any of claims 1 to 4 wherein the amount of said corrugated board stock added to said water ranges between ½ and 10% by weight of said water.

6. A method in accordance with any of claims 1 to 5 wherein the temperature of

said water used to form said dispersion ranges between ambient temperature and about 160°F.

7. A method in accordance with any of claims 1 to 6 wherein said mechanical action is carried out over a period of time ranging from a few seconds to several minutes.

8. A method in accordance with any of claims 1 to 7 wherein said separating comprises collecting said kraft linerboard fraction on a screen sized to permit said corrugated medium fraction to pass therethrough.

9. A method in accordance with any of claims 1 to 8 wherein said small pieces of said corrugated medium fraction are no larger than about 3/8 inch on a side.

10. A method for separating the semichemical fibre fraction forming the corrugated medium from the kraft fibre fraction forming the linerboard in corrugated board, substantially as described in the foregoing specific example.

11. A method in accordance with any of claims 1 to 10 including the further step of separately dispersing said semichemical corrugated medium and said kraft linerboard fractions in water to form separate papermaking furnishes.

12. A method in accordance with claim 11 including the further step of forming from said papermaking furnishes reconstituted papers suitable for corrugated medium and for linerboard in the manufacture of corrugated board.

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